3.1 THE JPL 15-YEAR LIDAR BACKSCATTER ARCHIVE: A RETROSPECTIVE

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1. INTRODUCTION

Since its inception in 1984 the Jet Propulsion Laboratory (JPL) coherent CO_2 lidar facility has acquired a 15-year time series of atmospheric backscatter profiles above the lidar site in Pasadena, California. The facility is located approximately 390 m above Median Sea Level (MSL) at geographical coordinates 34° 12' N; 118° 10' W. The lidar was commissioned with a charter to provide range-resolved absolute backscatter profiles throughout the troposphere and lower stratosphere. The inversion algorithm and radiometric calibration procedure that were developed in order to accomplish this requirement have been previously described by Kavaya and Menzies (1985) and Ancellet *et al.* (1988).

Techniques developed with the aid of this facility were also instrumental in the successful design and fielding of an airborne analog of this lidar (Menzies and Tratt, 1994) which participated in the GLOBE (Global Backscatter Experiment) surveys of the Pacific backscatter environment which were conducted in 1989-90 (Menzies and Tratt, 1997).

The backscatter profile archive generated by the JPL lidar provides a valuable tool for the long-term study of atmospheric aerosol backscatter and extinction in the 9-11 micron spectral region and has yielded considerable insight into historical trends, the impact of major volcanic eruptions on the atmospheric aerosol loading and the associated atmospheric transmittance, seasonal influences on the aerosol sources and sinks, convective coupling of boundary layer and free tropospheric aerosol populations, and the elucidation of backscatter statistical properties. In addition, data collected by the lidar have also made contributions to the investigation of selected meteorological case studies (Menzies *et al.*, 1989; Tratt *et al.*, 1999).

2. INTERANNUAL AND SEASONAL EFFECTS

The 15-year perspective offered by the JPL database enables temporal studies of backscatter behavior on seasonal to interdecadal timescales. Past analyses have revealed robust seasonal variations with annual and semi-annual moments that vary considerably as a function of altitude (Menzies *et al.*, 1989; Menzies and Tratt, 1995). For example, tropospheric altitudes exhibit a pronounced enhancement in prevailing backscatter levels during the northern spring (as is evident from Figure 1a). This observation is attributable to increased convective pumping of material originating from the planetary boundary layer and also to the prevalence of Asian-sourced refractory aerosol at that time of year (a particularly prominent example of which was observed in April, 1998; Tratt *et al.*, 1999).

Seasonal analysis of coupled backscatter behavior in the upper troposphere and lower stratosphere suggested that sedimentation is less important a process than stratosphere-troposphere exchange mechanisms at mid-latitudes in removal of particulate matter from the stratosphere (Menzies and Tratt, 1995).

The eruption of Mt. Pinatubo in 1991 was perhaps the most thoroughly observed in history, and this statement extends also to its atmospheric impact. In common with several other lidar systems around the globe, the JPL lidar operated throughout the growth and decay stages of the resulting atmospheric aerosol perturbation and acquired a valuable time series of profiles tracing the evolution of the eruption cloud, especially in the stratosphere (Tratt and Menzies, 1994 and 1995). Figure 1b traces the stratospheric backscattering strength through this era and beyond into the current volcanically quiescent period, where backscatter values have now declined ostensibly to background levels. Figure 2 compares the Pinatubo-era altitude-dependent mean backscatter with the pre-Pinatubo conditions as observed above the JPL lidar site. The extended period of aerosol residence at the ~18-km MSL level accords with the findings of other lidar stations around the globe (e.g., Haner *et al.* 1993; Jäger *et al.*, 1995). Each of these profiles

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represents a geometric mean of approximately one year of data.

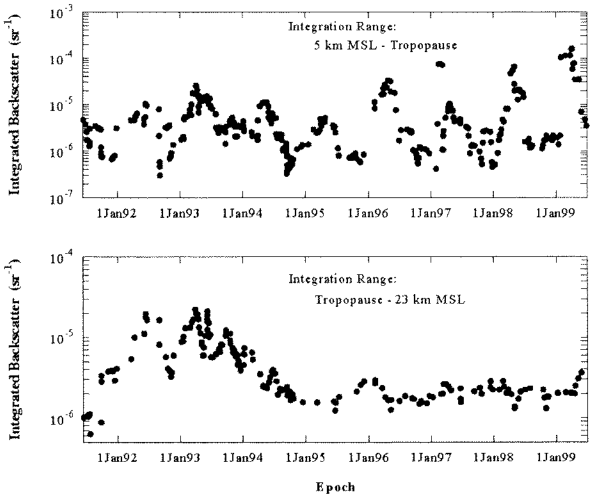

Figure 1. Time-series integrated backscatter in the post-Pinatubo era for (a) the free troposphere, and (b) the lower stratosphere.

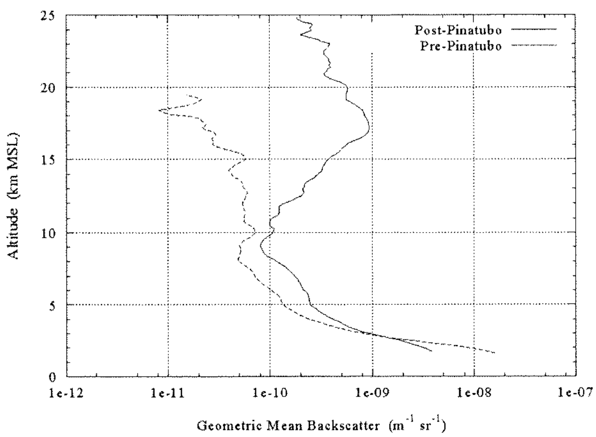

Figure 2. 12-month geometric mean backscatter above JPL for the pre- and post-Pinatubo periods.

By mid-1995 the Pinatubo stratospheric perturbation as observed from JPL had been in the decay phase since the beginning of 1993 (as evidenced by Fig. 1b), with the overall stratospheric loading having subsided virtually to the ultra-clean pre-Pinatubo conditions (Tratt and Menzies, 1995). Subsequently, the JPL lidar observations recorded a major event in which the integrated stratospheric backscatter exceeded by a significant degree the then prevalent background level. This feature persisted throughout the winter of 1995/96 and has been interpreted as being due to a tropical stratospheric reservoir migration into mid-latitudes (Mims, 1997).

3. EPHEMERAL EVENTS

Although the majority of data products extracted from the JPL backscatter profile database relate to long-term behavior, on certain occasions the lidar has also been applied to observe phenomena of a more transient nature. Thus, in late April of 1998 the facility was used to track a particularly extreme instance of dust incursion into Southern California originating from a severe storm which occurred several days earlier in the Central Asian desert (Tratt *et al.*, 1999).

The first observation of this event from the JPL site was on April 27, 1998. Its evolution was subsequently tracked by the lidar throughout the ensuing week, and had substantially dissipated when the onset of protracted stormy conditions on May 2 obscured the final decay stages. The solid curve in Figure 3 shows the lidar backscatter profile acquired on May 27, 1998, at the peak of the event as observed from JPL. The accompanying dashed curve, acquired on May 1, 1998, depicts the near-background conditions that were observed after the dust had sedimented out from the free troposphere, while the dotted curve denotes the system sensitivity. Note that the Asian dust gave rise to peak backscatter coefficients at least two orders of magnitude above the prevailing upper tropospheric background conditions.

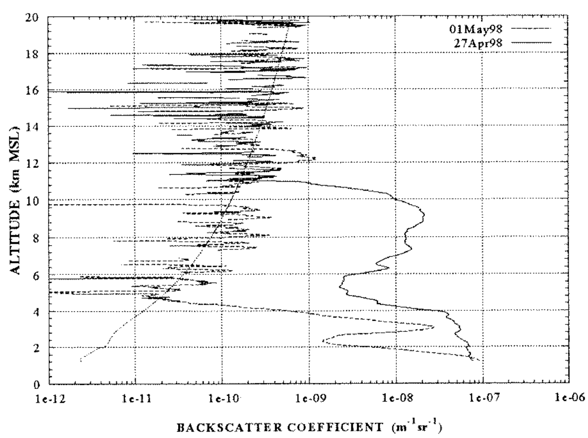

Figure 3. Lidar backscatter observation of an extreme Asian dust event in April, 1998.

4. BOUNDARY LAYER MEASUREMENTS

In order to assist with the process of compensating for attenuation losses in the data inversion algorithm (Kavaya and Menzies, 1985), boundary layer backscatter and attenuation profiles associated with the corresponding vertical profiles have been routinely recorded throughout the extent of the database collection activity. A multiyear time series of this data is shown in Figure 4.

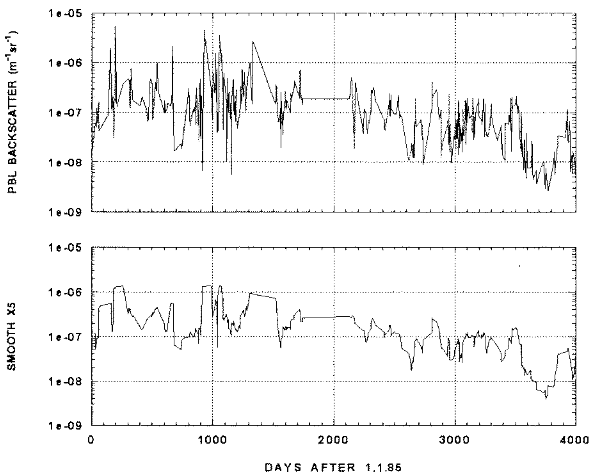

Figure 4. Time-series (upper panel) and smoothed (lower panel) boundary layer backscatter in the northern Los Angeles Basin, as observed from JPL.

Preliminary analysis of these data, along with comparison against local PM_{10} particulate records, has revealed similarities in general trends during the last few years as stringent air quality regulations resulted in significant reductions in anthropogenic aerosol generation. The JPL database is particularly sensitive to human activity in the boundary layer due to the peak-hour bias in time of acquisition (see Figure 5).

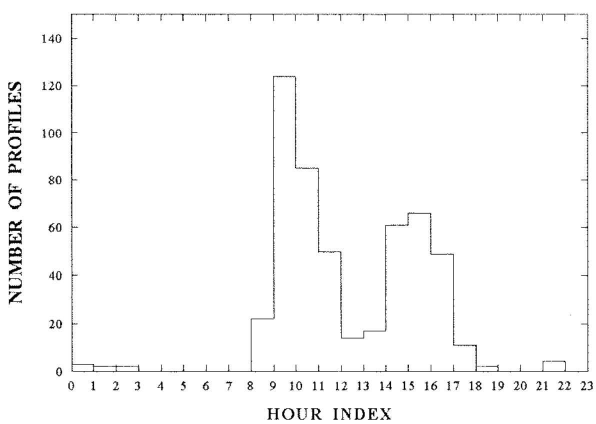

Figure 5. Diurnal distribution of the horizontal backscatter measurements compiled in Fig. 4. The hour index is expressed with reference to local time.

5. CONCLUSION

The JPL aerosol backscatter climatology database has enabled considerable insight into seasonal, annual, and interannual variability, as well as perturbations induced by significant transient events, in the free troposphere and lower stratosphere.

Future plans for this ongoing activity include correlative intercomparisons against data obtained with complementary collocated sensors to leverage the science products available from the dataset.

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